BY ORDER OF THE SECRETARY OF THE AIR FORCE

AIR FORCE OCCUPATIONAL SAFETY AND HEALTH STANDARD 91-90
1 MAY 1997

Safety

PRECISION MEASUREMENT EQUIPMENT LABORATORY (PMEL)

The criteria in this standard are the Air Force's minimum safety, fire prevention, and occupational health requirements. Major commands (MAJCOM), direct reporting units (DRU), and field operating agencies (FOA) may supplement this standard when additional or more stringent safety and health criteria are required. Refer to Air Force Instruction (AFI) 91-301, *Air Force Occupational and Environmental Safety, Fire Protection, and Health (AFOSH) Programs*, for instructions on processing supplements or variances and reporting conflicts in guidance between this standard, federal standards, or other Air Force directives.

This standard applies to PMEL operations in areas covering chemicals, gases, metals, ultrasonic, radiation, electrical, electronic, electromechanical, and visual inspection disciplines. This standard provides Air Force personnel with guidance on safety, fire prevention, and occupational health while performing PMEL operations. AFOSH Standard 91-50, *Ground Communications Electronics (C-E) Systems*, shall NOT be used in conjunction with this standard because of the inherent differences between C-E system maintenance and PMEL operations. This standard implements regulatory portions of applicable Occupational Safety and Health Administration (OSHA) standards and Air Force criteria not addressed in the OSHA Standards. National Stock Numbers (NSNs) are provided as reference sources only. Unit supply representatives will be contacted for assistance.

SUMMARY OF REVISIONS

Administrative changes have been made to update this standard to electronic format. Paragraphs have been renumbered as well as reference changes from AFRs to AFIs. A ★ indicates revisions from the previous edition.

1. Hazards/Human Factors. Personnel engaged in PMEL operations are exposed to several potential hazards. They include, but are not limited to, exposure to flammable and combustible liquids and gases and absorption of toxic and hazardous chemicals/materials. Also, PMEL personnel are subject to some of the physical injuries associated with other job environments. Particular attention must be given to protection against exposure to toxic chemicals and ionizing radiation, since the effects of any exposures are not always apparent immediately or in the near future. Potential physical and health hazards can be effectively controlled by following the guidance in this standard, by proper work procedures, controls, and facility design, and by using protective equipment and clothing.

1.1. Electricity. Any voltage, alternating current (AC) or direct current (DC), has the potential to interfere with normal heart action. The severity is determined by the amount of current flowing through the body, the path of current flow, the time of exposure, and the body's physical condition. Safe electrical work practices, safe equipment, and approved grounding and bonding procedures are essential to the prevention of electrical mishaps. The amount of electrical equipment used and tested in PMEL operations is considerable, and this subject has been addressed in detail in paragraph 2.8.

1.2. Laser Radiation. Refer to AFOSH Standard 161-10, *Health Hazards Control for Laser Radiation*, for guidance on the prevention of harmful effects to personnel resulting from exposure to laser radiation.

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1.3. Radiofrequency (RF) Radiation Hazards. RF radiation produces heating in body tissues. Absorption by specific body organs depends upon the frequency of the RF radiation. It is possible for a person to absorb damaging amounts of RF radiation in deep tissue and organs with little or no sensation of skin heating. AFOSH Standard 161-9, *Exposure to Radiofrequency Radiation*, gives guidance on the management of hazards associated with RF radiation.

1.4. Radioactive Materials. Radioactive materials are found in calibration sources, check sources of detection instruments, and electron tubes. Calibration sources pose the greatest hazard because of the intensities involved. Check sources become hazardous when broken or touched directly. Radioactive electron tubes may pose a hazard when broken or stored in large quantities. Damage to the body can occur through exposure to gamma rays from open calibration sources and from unsealed radioactive materials if they are inhaled, ingested, passed through openings in the body or open wounds, or absorbed through the skin.

1.5. Mercury. Liquid mercury is used in pressure and temperature measuring instruments. This liquid can enter the body through the lungs, skin, and digestive system, but breathing the vapor is the most common cause of mercury poisoning. Mercury vaporizes at temperatures as low as +10 degrees F. Since mercury vapors are colorless and odorless, they may be present anywhere mercury is used. When spilled, liquid mercury breaks up into tiny beads that lodge in cracks, mix with dust, and penetrate such porous materials as wood or tile.

1.5.1. Exposures to high levels of mercury can cause acute poisoning characterized by a metallic taste, tightness and pain in the chest, difficulty in breathing, fever, diarrhea, and headaches. Acute poisoning, however, is rare. Much more common among workers is chronic poisoning caused by long-term exposure to lower levels of mercury. Symptoms of chronic poisoning include inflammation of the mouth and gums, weakness, increase in saliva, loss of appetite and weight, and impaired digestive and kidney functions.

1.5.2. Enough mercury can accumulate on working surfaces to cause a serious health hazard. Mercury also can cling to clothing, especially knitted fabrics, and to shoe soles. A worker can easily take a health hazard home without being aware of it.

1.6. Hydrazine Exposure. Hydrazine is a clear, oily liquid having an ammonia-like odor. It can be absorbed through the skin, swallowed, or inhaled. Because individual sensitivity to the odor may vary and prolonged exposure can overcome sensory recognition, the odor cannot be relied upon as an indication of warning of exposure. If exposed to high concentrations of hydrazine for short periods, individuals may experience dizziness, nausea, or irritation of the eyes, nose, throat, or lungs. Liquid contact may cause skin burns. Very high concentrations may cause unconsciousness. Damage to kidneys and liver may occur if a worker is exposed over a long period of time to concentrations of hydrazine above the permissible exposure limits identified in AFOSH Standard 161-9 and AFOSH Standard 48-8, *Controlling Exposures to Hazardous Materials*. A yellow discoloration of the skin and eyes may be apparent.

1.7. Compressed Gases/Oil. Some testing and calibrating operations require the use of compressed air and oil at pressures of 4,000 pounds per square inch (psi) or more. An oil leak at these pressures produces a high velocity stream of oil that penetrates the skin and injects oil into body tissue. These high pressure injections can cause severe localized circulatory system damage which may require surgical treatment and can cause possible loss of the injured extremity. Even with low pressure -- high volume systems, there is considerable danger to personnel because of the amount of energy stored in the system. Compressed gases commonly found in PMELs are air, nitrogen, and methane.

1.7.1. Air. Air is a colorless, odorless, and tasteless gas. Compressed air is used in PMEL operations to calibrate and clean equipment.

1.7.2. Nitrogen. Nitrogen (N_2) is a colorless, odorless, and tasteless gas which liquefies at -195 degrees C It is capable of becoming an asphyxiant by displacing available oxygen. This can create an oxygen-deficient atmosphere with a potential of causing a worker to become dizzy or unconscious or possibly leading to death. In addition, liquid nitrogen, because of its extremely low temperature, can cause damage to body tissues similar to frostbite. N_2 is used in PMEL operations for pressure testing equipment, as an expellant of other gases from their cylinders, and for purging pipes, tubes, and lines.

1.7.3. Methane. Methane is a colorless, odorless, tasteless, highly flammable gas. Methane may also be an asphyxiant if it displaces available oxygen. This can create an oxygen-deficient atmosphere with a potential of causing a worker to become dizzy or unconscious or possibly leading to death.

1.8. Oxygen and Oxygen Equipment. Oxygen mixed with hydrocarbons creates a strong potential for a violent explosion.

2. General Requirements.

2.1. Housekeeping. A high standard of housekeeping is essential to safe operations in laboratories. Floors shall be kept free of spilled liquids to minimize the possibility of slipping and falling. In addition, dry floors are essential to electrical safety. All work and storage areas shall be kept clean. Equipment and materials shall be stored in a proper and orderly manner.

2.2. Wear of Jewelry. Personnel working on, with, or near energized electrical circuits shall NOT wear rings, watches, or other conductive objects that could increase shock risk, be the source of potentially severe burns, or cause a short circuit if dropped

in the equipment. Metal eyeglasses should be secured by a band or cord to prevent them from falling into energized electrical circuits.

2.3. Personal Protective Equipment (PPE). Engineering and administrative controls are the preferred means of protecting personnel. The use of PPE is supplemental to, but NOT a replacement for, such controls. Table 1 lists PPE required for frequently performed PMEL operations and areas of exposure. Data on PPE are also contained in AFOSH Standard 91-31, *Personal Protective Equipment*, and in several AFOSH standards in the 48-series. These latter standards are identified in the text where the specific subject is addressed.

2.4. High Voltage Emergency Equipment. Emergency equipment may be provided at each operating location (particular remote locations may require special considerations) where maintenance is performed on energized high voltage circuits. Operating location is defined as a place where some process or treatment is being carried out. Variations in the equipment will depend on local conditions. The equipment may be displayed on a board, stored in a cabinet, or made available in a portable kit-form. It should be situated in a conspicuous and prominent location, well marked, and readily accessible to personnel. If a board is used, the recommended size is 4 feet by 4 feet by one-half inch. Color coding is not mandatory; however, the recommended color is a dark green background with white letters and border. In each case, the color should be conspicuous against the background coloration of the particular facility. The following items may be included in an emergency equipment kit or board, when justified by the supervisor as a requirement:

- The safety Operating Instruction (OI), when required by the management for the particular site.
- CPR instructions. An American Red Cross or American Heart Association Poster may be used.
- Numbers of the servicing fire department and medical facility. These will be prominently displayed.
- First aid kit, NSN 6545-00-922-1200, if required by base medical services.
- Nonconductive hook with an electrical insulated handle with less than 180 degrees of bend.
- A 15-foot length of rope, preferably one-half inch hemp. Nylon rope has low flammability and softening point and should NOT be used.
- Insulated fuse pullers (where required).
- A flashlight (with a nonmetallic case) or a chemical high intensity light stick in operating condition.
- Grounding stick (shorting stick), if not required on adjacent work benches.
- Snake bite kit (where dictated by environmental conditions).
- Wool blanket.
- Insulating blanket.
- Building number (if not otherwise prominently displayed).
- Portable emergency signs constructed preferably of plastic, cardboard, wood, or other nonconductive materials approximately 5 inches high by 12 inches long. These should be provided with a nonconductive cord so they may be hung on equipment when needed. Various signs should be available reading: “Danger - Do Not Energize - Men Working on Antenna,” “Danger - Interlocks Disabled,” or other suitable commercially available substitutes. AFOSH Standard 91-45, *Safety, Health, and Fire Prevention Signs and Tags*, will be consulted.

Table 1. ★Frequently Performed PMEL Operations Where PPE is Required.

Operation	Type PPE
Battery Servicing/Handling (Wet Cell)	Eye protection (side and frontal) Gloves, rubber Apron, rubber
Cathode Ray Tube Installation or Removal	Face shield/ Safety glasses Gloves
Heavy Lifting	Safety-toe shoes
Compressed Air Cleaning	Eye protection (side and frontal)
Laser Operations	Protective goggles (Special) (refer to AFOSH Standard 161-10)
Use of Hydrazine Related Equipment	Respirators (when engineering controls and work practices are not sufficient to reduce exposures to below the permissible exposure limit)

Operation	Type PPE
	Impervious gloves (refer to AFOSH Standard 48-8)
Liquid Nitrogen Handling	Face shield Apron, rubber Gloves, insulated Long sleeve garment
Oil Analysis Instrument Testing	Light shields and filters
Mercury Servicing/Clean-up	Rubber gloves Respirator (appropriate for mercury) Goggles
Working in Hazardous Noise Area (Noise Level 85 Decibels (dB) or Greater)	Hearing protection
Soldering	Respirator (when Bioenvironmental Engineer (BEE) determines area ventilation is inadequate) Eye protection (side and frontal) Face Shield or safety goggles (Normal prescription glasses or plain safety glasses may be used in place of safety goggles for *light* electronic equipment soldering.)
Liquid Fluorocarbon (Freon)	Impervious gloves Eye protection (side and frontal)

2.5. Ventilation Systems. As a minimum, PMEL areas requiring positive ventilation are cleaning areas and laboratory work areas. Ventilation shall continue for a sufficient time after job completion to minimize residual vapors. Adequate makeup air will be provided. For more details (including information on permissible exposure levels, flow rate requirements, and design criteria) AFOSH Standard 161-2, *Industrial Ventilation*, AFOSH Standard 48-8, *Controlling Exposures To Hazardous Materials*, Air Force Manual (AFMAN) 32-1094, *Criteria for Air Force Precision Measurement Equipment Laboratory Design and Construction*, and Technical Order (TO) 0020-14, *Air Force Metrology and Calibration Program*, will be consulted.

2.6. Occupational Health:

2.6.1. Ionizing Radiation. Personnel who may be exposed to ionizing radiation during the normal course of their duties shall be entered into the personnel dosimetry program (AFI 48-125, The US Air Force Personnel Dosimetry Program) when determined necessary by the Base Radiological Protection Officer. Areas used for calibration should be kept separate where possible and restricted to those persons directly involved in calibration operations.

2.6.2. Nonionizing Radiation. Nonionizing radiation, especially the higher radio frequencies and ultraviolet rays, can cause injury depending on several factors, for example, body characteristics, level of radiation (power), length of exposure, etc. Use of protective devices such as shields, guards, and dummy loads shall be used as applicable to minimize exposure. In those instances where exposure is inherent to the task being performed, the length of exposure will be minimized. Looking directly into waveguides, ultraviolet sources, etc., will be avoided.

2.6.3. New Chemicals, Machines, or Processes. All new situations will be evaluated by the Base Bioenvironmental Engineers, Safety, and Fire Department staffs, as appropriate, prior to introduction into the work area. Once approved, supervisors will train all personnel prior to using the new chemicals, machines, or processes.

2.6.4. Ultrasonic Cleaning. When using ultrasound cleaning equipment, workers will always follow the manufacturer's instructions for cleaning the specific part(s) in question. (TO 00-25-234, *General Shop Practice Requirements for the Repair, Maintenance, and Test of Electronic Equipment (ATOS)*, and Military Specification (Mil Spec) C-24196, *Cleaning System Ultrasonic, Console*, will be consulted.)

2.6.5. Soldering Precautions. The health hazard potential of any soldering operation depends on the types of filler metals, fluxes, coatings, cleaning agents, gases, and base metals used and upon exposure. It is important to know what materials are being used. Electrical solder (resin core, lead alloy) is the most commonly used solder in PMEL operations. Adequate ventilation shall be provided when using this solder to preclude inhaling the fumes and vapors (table 1 will be consulted). If

other type solders are used, AFOSH Standard 91-5, *Welding, Cutting, and Brazing*, or TO 00-25-234 will be consulted for guidance on needed protective measures.

2.6.6. Mercury Precautions. All equipment containing mercury should be properly maintained to prevent escape of mercury liquid, vapor, or dust. Containers of mercury will be kept tightly capped to prevent vapors from escaping. Waste mercury or waste materials contaminated by mercury should be placed in vapor-tight containers until disposal. The base BEE and Environmental and Contract Planning Office (CEV) will be consulted for local procedures for the proper disposal of contaminated mercury and for handling mercury spills. Areas where mercury is used should be kept separate from other work areas where possible and should be restricted to those workers directly involved in the mercury operations (TO 42C-1-18, *Control, Decontamination, and Disposal of Mercury*, will be consulted). Carpets will NOT be placed in areas where mercury will be used.

2.6.7. Noise-Suppression Devices. In noise hazard areas (85 dB or greater), as determined by the BEE, PMEL maintenance personnel will wear appropriate hearing protection.

2.7. Fire Prevention:

2.7.1. AFOSH Standard 91-43, *Flammable and Combustible Liquids*, will be consulted for guidance on the storage, use, and handling of flammable and combustible liquids. In addition, the base fire department and AFOSH Standard 91-56, *Fire Protection*, will be consulted for guidance on the selection and placement of fire extinguishers.

2.7.2. PMEL supervisors will ensure that:

- Personnel are trained on the location, selection, and use of fire extinguishers, alarm systems, main power switches, and evacuation procedures.
- Fire extinguishers are securely mounted, readily accessible, in a serviceable condition, and clearly visible.
- All exits are clearly identified, posted with signs, kept unlocked, easily accessible, and clear paths of travel are provided. The base fire department and base safety office will be consulted for guidance on emergency lighting.
- Smoking is NOT permitted in the immediate area where flammable materials are being dispensed or used.
- Soiled rags, paper towels, craft paper, and other trash contaminated with oil or grease are placed in self-closing metal safety cans marked and color-coded to indicate contents. At the end of each shift, these containers shall be emptied or placed in an approved location outside the shop for pickup or disposal. Clean rags will be kept in covered metal containers or in lockers.

2.8. Electrical Safety for PMEL Operations:

2.8.1. Laboratory Floors. Laboratory floors shall be covered with sheet vinyl floor covering of the dielectric type specified in AFMAN 32-1094. If floor coverings other than this are used, then insulated mats, NSN 7220-00-255-0765 (Black - 24 inches wide), 7220-00-267-4630 (Blue - 36 inches wide), or 7220-00-913-8751 (Green - 36 inches wide), are required when personnel are exposed to and working on energized high voltage circuits.

2.8.2. Equipment Grounding. Most 110 volt AC/DC equipment can and will be grounded using a three wire cord/plug/wall receptacle system unless equipment is double insulated. However, some equipment will not operate with their cases grounded. Other equipment requires an ungrounded case for calibration. Local in-house procedures will be developed and defined to cover these situations. All wall receptacles will be checked for ground continuity and for resistance of 10 ohms or less. Equipment requiring 220 volt or higher input voltage will be grounded following National Electric Code (NEC) or manufacturer's recommendations. Fixed electrical equipment will be electrically bonded to a grounding connector. Special protection will be provided to safeguard grounding wires from mechanical damage. Most electrical equipment is assembled with the outer case electrically isolated from internal components and the case will be separately grounded. The manufacturer's manual or OSHA Standards 29 CFR 1910.303, *General Requirements*, .304, *Wiring Design and Protection*, .305, *Wiring Methods, Components, and Equipment for General Use*, and .308, *Special Systems*, will be consulted.

2.8.3. Workbenches. Metal topped workbenches will be grounded to the facility ground (workbenches with insulated, nonconductive tops are considered to be isolated from ground). All isolated workbenches will have a grounding point provided for use when a grounded workbench is required for operations such as Electrostatic Discharge (ESD) operations. All workbenches isolated from ground will have a switch or circuit breaker installed to allow the bench to be grounded when necessary. The grounding point shall be connected to the facility ground and will NOT be connected to the technical ground. Connection to a metal raceway or conduit is NOT an acceptable method of grounding.

NOTE: For electrostatic discharge control procedures, TO 00-25-234 will be consulted.

2.8.4. Mobile Equipment Grounding. System grounding of mobile equipment will be done by means of a separate insulated equipment grounding conductor.

2.8.5. Buss Bars. Buss bars will be clean and free of corrosion.

2.8.6. Facility Ground. The facility ground will be marked at its connection to the ground buss bar. If the connection is outdoors, it will be coated with no-ox grease and marked in accordance with TO 31-10-24, *Air Force Communications Standard Installation Practices*, and the requirements of the Base Civil Engineer (BCE). The electrical and grounding systems

will be visually inspected (monthly) by the facility custodian for security and damage. After repairs to electrical outlets are completed, they should be tested for continuity and polarity by a qualified electrician.

2.8.7. Equipment Electrical Safety Devices:

- The doors to equipment racks and enclosures will be closed at all times except to facilitate necessary and authorized repairs.
- Interlocks will NOT be disabled during maintenance or adjustments unless prescribed by the manufacturer's manual or applicable TOs. During these periods, a sign stating "Danger - Interlocks Disabled" or other suitable commercially available substitute will be placed on the equipment. Interlocks will NOT be permanently disabled or bypassed (29 CFR 1910.306, Specific Purpose Equipment and Installations, will be consulted).
- Only authorized maintenance personnel will perform repair work on equipment with defective interlocks (29 CFR 1910.303, .305, and .306 will be consulted).
- When personnel are exposed to and working on energized high voltage (600 volts nominal or more) circuits, safety observers will be present unless the area supervisor determines the degree of risk of the operation does not warrant a safety observer.

2.8.8. Fuses and Circuit Breakers (29 CFR 1910.306):

- Circuit breakers or fuses will NOT be bypassed and will be installed in all electrical circuits of a size and type to interrupt the current flow when it exceeds the current carrying capacity of the conductor and/or circuit.
- Equipment fuses will always be replaced by fuses of the size and type required by the manufacturer's manual. Insulated fuse pullers will be used to remove and replace cartridge fuses. Wire, tinfoil, solder, or other conductive materials will NOT be used as substitutes for fuses. A lower amperage fuse of the same type may be used as a temporary measure until the proper fuse is available.

2.8.9. Grounding Sticks. A grounding stick will be available for use at all electronic work stations.

2.8.10. Adjustments and Testing of Equipment:

- Electrical power will be disconnected before technicians perform mechanical adjustments or repairs not involving alignment of mechanical/electrical parameters. Mechanical/electrical adjustments with power on will only be accomplished when required by applicable TOs or manufacturer's manual to align mechanical/electrical parameters which cannot be made with power removed. Technicians performing the adjustment/alignment will use the insulated tools to minimize the possibility of damage to active components or electrical shock.
- Technicians will NOT use lead pencils, screwdrivers, or other hand tools to make radiofrequency energy tests (on any piece) of electronic equipment.

2.8.11. Power Distribution Panels/Controls. Main power switches should be conspicuously marked. All personnel will know the location and on-off operation of the main power distribution panels in their work areas. This knowledge is essential to disengage electrical circuits to equipment in the event of a fire or accidental electrical contact. Except for 110 volts 60 hertz (HZ) outlets, all electrical fuse, switch, and circuit-breaker boxes will be plainly marked with the voltage, phase, and frequency of the circuit and will be marked to identify exactly what they control. (29 CFR 1910.304 and .306)

2.9. Equipment/Component Cleaning:

2.9.1. Vacuuming is the preferred method for cleaning electronic equipment. The preferred accessories are nonmetallic wand and suction nozzle. If compressed air is used, the air pressure will be limited to the lowest possible level. Generally, 5 psi is adequate for equipment cleaning; however, pressures will NOT exceed 30 psi. A diffuser nozzle will be provided (TOs 00-25-234 and 31-1-75, *Maintenance Engineering Standard--General Maintenance Practices*, will be consulted).

2.9.2. If solvents are required, only approved and authorized ones will be used. The base BEE will be consulted if there is doubt about the characteristics of a solvent. Adequate ventilation will be provided. AFOSH Standard 161-2 contains information on ventilation requirements. Appropriate PPE, as listed in table 1, will be worn.

2.10. Tools and Equipment:

2.10.1. Insulated tools will be used when performing work on energized equipment. Placing rubber grips or tape on uninsulated tools does NOT make them acceptable as insulated tools. Wooden handle tools will NOT be issued or used.

2.10.2. Wood or fiberglass ladders are the only acceptable ladders for work on or near electrical equipment (AFOSH Standard 91-22, *Walking Surfaces, Guarding Floor and Wall Openings and Holes, Fixed Industrial Stairs, and Portable and Fixed Ladders*, will be consulted).

2.10.3. Ground wrist straps will be disconnected when personnel are exposed to and working on energized electrical circuits.

2.11. Training:

2.11.1. Personnel will receive the proper ionizing and nonionizing radiation safety training from the base Radiological Protection Officer.

2.11.2. CPR training shall be provided for those people whose normal daily job requires them to work on energized high voltage electric circuits. The PMEL supervisor will identify personnel who require this training.

2.12. Safety Observer. A person trained in CPR will be present as a safety observer during exposure to high voltage energized circuits during work situations unless the area supervisor determines the degree of risk of the operation does not warrant a safety observer.

3. Specific Applications.

3.1. Calibration/Repair of Fluid Analysis Equipment. Precautions to be exercised when performing oil analysis operations/ maintenance include consideration of exposure to acids, electric current, and petroleum distillates. Maintenance technicians will NOT attempt repair or calibration of this equipment unless they have received the formal training required by the appropriate TO.

3.2. Calibration/Repair of Radiation Measuring Equipment. AFOSH Standards 161-9 and 161-10, and TO 00-110N-3, *Requisition, Handling, Storage, and Identification of Radioactive Material*, shall be complied with before radiation PMEL is calibrated or repaired. The following precautions are in addition to those normally observed by personnel engaged in the use and storage of this equipment. Special problems not covered in this standard and the referenced AFOSH standards, manuals, and TOs will be referred to the base BEE and Radiological Protection Officer.

3.2.1. Radioactive material will be handled in a manner that results in exposures to personnel as low as reasonably achievable (ALARA). The base BEE and Radiological Protection Officer will prescribe special procedures and precautionary measures as necessary. In overseas areas the requirements are dictated by the agreement between nations for disposal procedures.

3.2.2. Personnel will NOT handle or in any way expose a radioactive source unless required to do so in the performance of duty. Personnel involved in the actual use of radioisotopes shall receive formal training in their use and the precautionary measures to be observed, followed by continuing on-the-job training (OJT). No one will be authorized to use, handle, or be allowed into any area with an exposed or open ionizing radiation source, without being entered into the USAF Personnel Dosimetry Program.

3.2.3. In restricted areas where radioactive material is used or stored, appropriate placards will be posted conspicuously at each entrance and around the exterior perimeter of each area so at least one placard is clearly visible from any direction of approach. Obstacles, such as rope, barricades, etc., shall be set up to discourage entry of unauthorized personnel into controlled areas. Individual containers of radioactive material within the area will be appropriately identified.

3.2.4. Women known or suspected to be pregnant will be denied access to Radioactive Detection, Identification, and Computation (RADIAC) calibration areas pending evaluation by the local BEE. The BEE will determine the woman's ability to perform radiation duties.

3.2.5. Personnel will wash their hands and face before eating or smoking (mandatory requirement) when working with radioactive material and upon leaving a contaminated area. Smoking, eating, or drinking in any area in which a radiation ingestion hazard may exist is strictly forbidden.

3.2.6. Regardless of radiation intensity, radioactive items used in PMEL operations will NOT be carried in pockets or clothing of personnel.

3.2.7. Positive measures, such as locked or guarded gates or doors in addition to placards, shall be established to prevent unauthorized entry into high radiation areas. Personnel entry into a high radiation area will energize a conspicuous visible or audible alarm signal designed to alert personnel present or cause the exposure to terminate. A high radiation area is defined as the area where a radiation source is equal to or greater than 130 curies.

3.2.8. In case of broken or damaged containers of radioctive materials, the area will be cleared of all personnel not required in evaluation of the condition, recovery of the radioisotope, or decontamination of the area or materiel. The area will be secured. In cases of air suspension of radioactive material, doors and windows will be closed and ventilation equipment turned off. The PMEL supervisor, base BEE, and Radiological Protection Officer will be notified immediately. A survey of the area will be conducted to determine the extent of the radiological hazard. Personnel who have been or may have been exposed will be monitored to determine the extent of medical action required. The Radiological Protection Officer will direct the decontamination or recovery operation as necessary. Broken or damaged items will be safely packaged and disposed of in accordance with TO 00-110N-2, *Radioactive Waste Disposal*, and TO 00-110N-7, *Handling and Disposition of Radioactive Electron Tubes and Spark Caps*.

3.3. Cathode Ray Tube (CRT). Precautions will be taken to minimize the danger of breaking the glass envelope of CRTs.

3.3.1. Prior to handling a tube, momentarily ground all pin connections including the high voltage connection to preclude electrical shock.

3.3.2. Avoid scratching the glass of a tube since such scratches weaken the tube and can cause the tube to implode.

3.3.3. Remove tube from its carton face up by grasping the larger (bell) end. Avoid handling large tubes by the neck since the narrow portion of the tube is particularly susceptible to breakage from bumping or striking other objects. This procedure also minimizes strain due to mechanical misalignment.

3.3.4. Special handling instructions are provided by manufacturers for tubes having an external insulation coating applied to areas of the bell end. Avoid touching the coated areas.

3.3.5. Do NOT place a tube on its side on a flat surface. Instead, place the tube face down on a protective nonabrasive pad. If possible, do not remove the CRT from the carton until ready for installation.
3.3.6. Handle tubes to be disposed with the same precautions as for new ones. Destroy these tubes prior to disposal by placing them face down in an empty CRT carton and breaking the center guide (keying) pin. Remove the tube's high vacuum by breaking off the tip of the glass vacuum seal. Seal the container and make an access hole so a crowbar or other heavy rod can be driven through to break the glass envelope.
3.3.7. If broken glass from a tube cuts the skin, wash such cuts with soap immediately to remove dirt, phosphorus, or other contaminants and obtain medical attention.
3.3.8. Do NOT use carbon dioxide fire extinguishers to control a fire involving equipment containing CRTs. The thermal shock may cause the tube to implode. Always use dry chemical extinguishers for this purpose.
3.4. Radar and Microwave Equipment. Radar and microwave equipment are sources of RF radiation. Personnel will be instructed in the hazards of RF radiation prior to working on this equipment and will not be exposed to RF radiation levels above the permissible exposure limits in AFOSH Standard 161-9. Caution should be observed with open waveguide connected to an energized source of microwave radiation. High power densities can be found at wave guide opening because power is concentrated in a small area. An RF radiation warning sign will be posted in areas where access to power density levels in excess of the permissible exposure limit (AFOSH Standard 161-9 will be consulted).
3.5. Cleaning Oxygen Equipment. TOs 15x-1-102, *Maintenance Instructions ManualGeneral Care and Cleaning of Oxygen Gauges and Oxygen Device Related Test Equipment*, and 37C11-1-1, *Maintenance Instructions--Cleaning of Pressure Gauges Used on Liquid Oxygen Systems*, will be referred to when cleaning oxygen equipment). Positive controls will be used to ensure that oxygen equipment handled by PMEL is NOT contaminated by any foreign material.
3.6. Equipment Containing Mercury. TO 42C-1-18 will be consulted. The base BEE and local CEV will be consulted for local clean-up procedures. Exposure to mercury may be controlled through use of enclosed systems that isolate mercury processes, regular monitoring of the work environment, good housekeeping, and good personal hygiene to prevent contamination of clothing, food, and tobacco products.
3.7. Hydraulic and Pneumatic Pressure Systems. TO 00-25-223, *Integrated Pressure Systems and Components (Portable and Installed)*, explains safe operating procedures for this type equipment and shall be followed by all personnel using this equipment. Also refer to Air Force Joint Instruction (AFJI) 23-207, *Storage and Handling of Compressed Gases, Liquids in Cylinders, and of Cylinders*.
3.8. Exposure to Hydrazine. Hydrazine safety information can be found in AFOSH Standard 48-8. A mishap report shall be submitted on all incidents of hydrazine overexposure. In the PMELs, maintenance and calibration of some emergency power unit test sets and/or pressure gauges that are sources of possible hydrazine exposure will be marked or identified if used during exercises. This will make them readily identifiable to PMEL personnel to preclude the possibility of PMEL persons becoming unnecessarily exposed during test operations at bases that would not normally handle these sources.
3.9. Working With Lasers. Eye protection will be worn when working with laser equipment. The local BEE will be consulted for type required. Lasers shall be used in a controlled area which is guarded by appropriate warning devices (AFOSH Standard 161-10 will be consulted).

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★GLOSSARY OF REFERENCES, ABBREVIATIONS, ACRONYMS, AND TERMS

References

Air Force Instruction (AFI) 48-125, *The US Air Force Personnel Dosimetry Program*
AFI 92-301, Air Force Occupational and Environmental Safety, Fire Protection, and Health (AFOSH) Programs (formerly AFR 127-12)
Air Force Joint Instruction (AFJI) 23-207, *Storage and Handling of Compressed Gases, Liquids in Cylinders, and of Cylinders*
Air Force Manual (AFMAN) 32-1094, *Criteria for Air Force Precision Measurement Equipment Laboratory Design and Construction*
Air Force Occupational Safety and Health (AFOSH) Standard 48-8, *Controlling Exposures to Hazardous Materials* (formerly AFOSH Standard 161-8
AFOSH Standard 91-5, *Welding, Cutting, and Brazing*
AFOSH Standard 91-22, *Walking Surfaces, Guarding Floor and Wall Openings and Holes, Fixed Industrial Stairs, and Portable and Fixed Ladders* (formerly AFOSH Standard 127-22)
AFOSH Standard 91-31, *Personal Protective Equipment* (formerly AFOSH Standard 127-31)
AFOSH Standard 91-43, *Flammable and Combustible Liquids* (formerly AFOSH Standard 127-43)
AFOSH Standard 91-45, *Safety, Health, and Fire Prevention Signs and Tags*(formerly AFOSH Standard 127-45)
AFOSH Standard 91-56, *Fire Protection* (formerly AFOSH Standard 127-56)
AFOSH Standard 161-2, *Industrial Ventilation*
AFOSH Standard 161-9, *Exposure to Radiofrequency Radiation*
AFOSH Standard 161-10, *Health Hazards Control for Laser Radiation*
Military Specification (Mil Spec) C-24196, *Cleaning System Ultrasonic, Console*
National Fire Protection Association (NFPA) 70, *The National Electric Code (NEC)*
Occupational Safety and Health Administration (OSHA) Standard 29 Code of Federal Regulation (CFR) 1910.303, *General Requirements*
OSHA Standard 29 CFR 1910.304, Wiring Design and Protection
OSHA Standard 29 CFR 1910.305, *Wiring Methods, Components, and Equipment for General Use*
OSHA Standard 29 CFR 1910.306, *Specific Purpose Equipment and Installations*
OSHA Standard 29 CFR 1910.308, *Special Systems*
Technical Order (TO) 00-110N-2, *Radioactive Waste Disposal*
TO 00-110N-3, Requisition, Handling, Storage, and Identification of Radioactive Material
TO 00-110N-7, *Handling and Disposition of Radioactive Electron Tubes and Spark Caps*
TO 00-20-14, *Air Force Metrology and Calibration Program*
TO 00-25-223, Integrated Pressure Systems and Components (Portable and Installed)
TO 00-25-234, General Shop Practice Requirements for the Repair, Maintenance, and Test of Electronic Equipment (ATOS)
TOs 15x-1-102, Maintenance Instructions ManualGeneral Care and Cleaning of Oxygen Gauges and Oxygen Device Related Test Equipment
TO 31-1-75, Maintenance Engineering StandardGeneral Maintenance Practices
TO 31-10-24, *Air Force Communications Standard Installation Practices*
TO 37C11-1-1, Maintenance InstructionsCleaning of Pressure Gauges Used on Liquid Oxygen Systems
TO 42C-1-18, Control, Decontamination, and Disposal of Mercury

Abbreviations and Acronyms

AC−Alternating Current
AFI−Air Force Instruction
AFJI−Air Force Joint Instructions
AFOSH−Air Force Occupational Safety and Health
ALARA−As Low As Reasonably Achievable
BCE−Base Civil Engineer
BEE−Bioenvironmental Engineer
CRT−Cathode Ray Tube
DC−Direct Current
dB−Decibels
DRU−Direct Reporting Unit
ESD−Electrostatic Discharge

FOA−Field Operating Agency
HZ−Hertz
MAJCOM−Major Command
N_2 −Nitrogen
NEC−National Electric Code
NFPA−National Fire Protection Association
NSN−National Stock Number
OI−Operating Instruction
OJT−On-the-Job Training
OSHA−Occupational Safety and Health Administration
PMEL−Precision Measurement Equipment Laboratory
PPE−Personal Protective Equipment
PSI−Pounds Per Square Inch
RADIAC−Radioactive Detection, Identification, and Computation
RF−Radiofrequency
TO−Technical Order

Terms

Shall—Indicates a mandatory requirement.
Will—Is also used to indicate a mandatory requirement and in addition is used to express a declaration of intent, probability, or determination.
Should—Indicates a preferred method of accomplishment.
May—Indicates an acceptable or satisfactory method of accomplishment.
Bonding—The interconnecting of metal raceways, equipment cabinets, shields, etc., to the facility equipment system to eliminate the electrical potential of the individual pieces of equipment relative to each other.
Cardiopulmonary Resuscitation (CPR)—Emergency first aid treatment involving mouth-to-mouth resuscitation and closed chest heart massage.
Cathode Ray Tube (CRT)—A sealed evacuated glass tube containing an electron source and a phosphorous face often used to provide a visual image display. A television tube is a common example.
Combustible Liquid—A liquid having a flashpoint at or above 100 degrees Fahrenheit (F) (37.8 degrees Celsius ©).
Curie—A unit used for indicating the strength of radioactive sources in terms of the number of disintegrations per second in the source. One curie is equal to 3.7 x 1010 disintegrations per second.
Energized—A circuit electrically connected to a source of potential difference or an electrical charge.
Equipment Ground—Connection to ground from one or more of the non-current carrying metal parts of the apparatus or equipment.
Facility Ground—A grounding system of 10 ohms or less that the entire third wire ground system, metal raceways, conduits, generators, transformers, and other equipment within the facility are connected to.
Flammable Liquid—A liquid with a flashpoint below 100 degrees F (37.8 degrees C).
Flashpoint—The minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.
Grounding Stick—A nonconductive handle, usually wood, with a conductive (metal) hook and grounding braid attached at a common point. The grounding stick is used to ensure that any voltage potential is neutralized prior to working on energized circuits.
Grounding System—Complete ground circuit for any equipment, facility, or system.
Hazardous Areas—Locations where chemical, physical, radiation, electromagnetic, or other hazards exist in such a manner that personnel safety or health may be jeopardized.
Hazardous Material—A substance which is explosive, flammable, poisonous, corrosive, oxidizing, irritating, or otherwise harmful and may cause personal injury or harm.
High Voltage—Any circuit, set of conductors, or exposed point of contact in which the potential to ground or between conductors is 600 volts nominal or greater.
Ionizing Radiation—Electromagnetic or particulate radiation, which has sufficient energy to produce direct ionization in passage through a substance. Examples of ionizing radiation are X-rays, gamma ray, alpha particles, and beta particles.
Nonionizing Radiation—Electromagnetic radiation which does not have sufficient energy to produce direct radiation when passing through a substance. Examples include radiofrequency (RF) radiation, visible light, infrared, and ultraviolet.

Radioactive Detection, Identification, and Computation (RADIAC)—A descriptive term referring to the detection, identification, and measurement of nuclear radiation.
Radioactive Electron Tubes—Electron tubes containing radioactive material.
Safety Observer—A worker who is trained in CPR and equipment turn-off procedures and who is responsible for administering immediate assistance to a technician in the event of an emergency (the safety observer may be the supervisor).
Technical Ground—A separate three ohm or less grounding system used and required in PMELs for calibration and repair of sensitive electronic equipment to provide a radiofrequency and electromechanical interference-free ground. This system is not a facility ground and should not be connected or bonded to any other grounding system.
Ultrasonic Cleaning—The loosening of oil and grease or other contamination from metal surfaces by the immersion of parts in a solvent or detergent solution in the presence of high-frequency vibrational energy.

PRECISION MEASUREMENT EQUIPMENT LABORATORY (PMEL)CHECKLIST

★This checklist addresses only minimum items to be inspected. Where appropriate, MAJCOMs/FOAs/DRUs, local safety offices, and supervisors will add to this checklist to include command or individual shop-unique requirements or situations.

1. Are floors kept clean of foreign materials and liquids? (Reference paragraph 2.1)

★2. Do personnel remove rings, watches, or other conductive objects when working on, with, or near energized electrical circuits? (Reference paragraph 2.2)

3. Is appropriate protective clothing available, kept serviceable, and worn as required? (Reference paragraph 2.3 and table 1)

4. Where required, is high voltage emergency equipment conspicuously and prominently situated, well marked, and readily accessible to personnel? (Reference paragraph 2.4)

5. Are portable emergency signs available for use? (Reference paragraph 2.4)

6. Is adequate ventilation provided where work is performed? (Reference paragraph 2.5)

7. Are areas used for calibration kept separate where possible and restricted to those persons directly involved in calibration operations? (Reference paragraph 2.6)

8. Are protective devices such as shields, guards, and dummy loads used to minimize exposure of personnel to nonionizing radiation? (Reference paragraph 2.6)

9. Have appropriate personnel been adequately trained in the use of chemicals, machines, or processes? (Reference paragraph 2.6)

10. Is adequate ventilation provided for soldering operations to prevent inhalation of gases, fumes, and vapors? (Reference paragraph 2.6)

11. Are there approved local procedures (BEE/CEV/SE) for the proper disposal of contaminated mercury and for handling mercury spills? (Reference paragraph 2.6)

12. Are flammable and combustible liquids handled, stored, and used as prescribed in AFOSH Standard 91-43? (Reference paragraph 2.7)

13. Is smoking prohibited in the immediate area where flammable materials are being dispensed or used? (Reference paragraph 2.7)

14. Are trash containers emptied or placed in an approved location outside the shop for pickup or disposal at the end of each shift? (Reference paragraph 2.7)

15. Are appropriate insulating mats provided when dielectric type sheet vinyl floor covering has not been used? (Reference paragraph 2.8)

16. Are all fixed electrical equipment electrically bonded to a grounding connector? (Reference paragraph 2.8)

17. Do all workbenches that are isolated from ground have a switch or circuit breaker installed to allow the bench to be grounded when necessary? (Reference paragraph 2.8)

18. Is a safety observer present when personnel are exposed to or working on energized high voltage circuits? (Reference paragraph 2.8)

19. Do all personnel know the location and on-off operation of the main electrical power distribution panels in their work area? (Reference paragraph 2.8)

20. If solvents are required when cleaning, are only approved and authorized ones used? (Reference paragraph 2.9)

21. Are only insulated tools used when work is performed on energized electrical circuits? (Reference paragraph 2.10)

22. Do personnel disconnect ground wrist straps when they are exposed to or working on energized electrical circuits? (Reference paragraph 2.10)

23. Do personnel receive the proper ionizing and non-ionizing radiation safety training from the base Radiological Protection Officer? (Reference paragraph 2.11)

24. Is CPR training provided for personnel who are identified by the PMEL supervisor as needing the training? (Reference paragraph 2.11)

25. Are persons trained in CPR utilized as system observers where required? (Reference paragraph 2.12)